National Aeronautics and Space Administration

Materials Characterization

High Temperature Emissivity Measurement System (HiTEMS)

NASA Marshall Space Flight Center

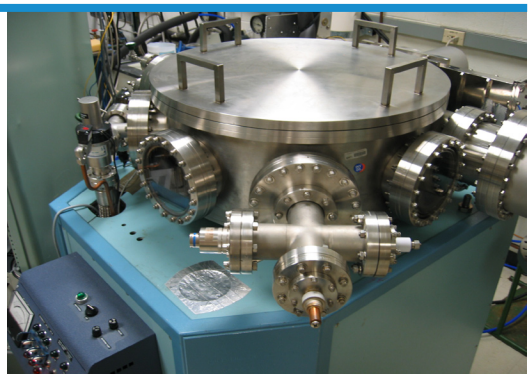
Spacecraft engine nozzles, radiator panels, habitat surfaces, and other space hardware remove unwanted heat by radiating it into the ambient vacuum environment. Two properties–temperature and emissivity–affect spacecraft materials as they transfer heat energy to the space vacuum. A material's emissivity is dependent not only on its composition but also on its surface finish and temperature. To maximize thermal efficiency of space-based and ground-based components operating in a vacuum environment, it is critical to measure emissivity of finished components over the entire range of the components' operating temperatures. Precise emissivity measurements over a range of temperatures and for a variety of materials are crucial for spacecraft design (especially radiators and rocket nozzles), thermal modeling (spacecraft and habitats), and vacuum processing (metal heating and casting, coating, and semiconductor processing).

Task Description

The Advanced Materials for Exploration (AME) program is developing a High Temperature Emissivity Measurement System (HiTEMS): a one-of-a-kind capability for measuring material emissivity at temperatures from 300 K (27 °C) to 3000 K (2700 °C). Tasks include

1. Designing and building two test systems
2. Developing a multi-wavelength, state-of-the-art optical diagnostic system for measuring emissivity
3. Calibrating and verifying both test systems on a variety of materials.

This 16-month effort was initiated in FY05, and the final design, fabrication, and verification testing of both new test systems will be completed in 2006. The test systems will be ready to conduct tests for customers in early 2007. HiTEMS will provide a unique capability for obtaining materials emissivity data over a broad range of operating temperatures. This information will be critical for design and development of the Crew Launch Vehicle, the Crew Exploration Vehicle and other spacecraft.

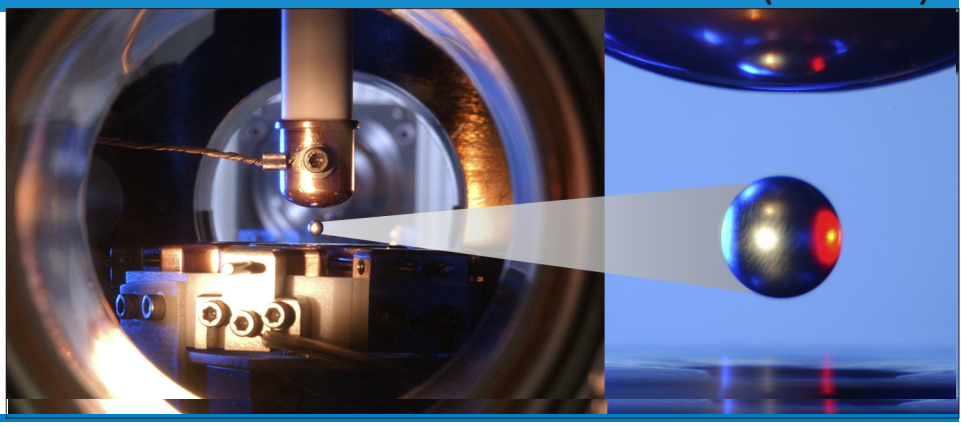


An existing vacuum chamber in the Marshall Space Flight Center (MSFC) Space Environmental Effects Laboratory is being outfitted with new instrumentation for making emissivity measurements on a variety of samples (homogeneous materials, composites, and painted or coated materials) at temperatures up to 1600 K (1327 °C).

advanced materials for exploration

HIGH TEMPERATURE EMISSIVITY MEASUREMENT SYSTEM (HiTEMS)

A solid metal sample is suspended by static energy from six electrodes inside the Electrostatic Levitator (ESL). The facility is being outfitted with new instrumentation for measuring the emissivity of small samples at temperatures ranging from 1600 to 3000 K (1327 to 2700 °C). Materials created as a result of the ESL tests include new optical materials, new metal alloys, special metallic glasses, and spacecraft components.



Anticipated Results

To cover this broad temperature range, HiTEMS comprises two test systems at NASA's Marshall Space Flight Center (MSFC). The first system uses contact heating in an existing vacuum chamber in the MSFC Space Environmental Effects Laboratory. It will provide emissivity information from 300 K (27 °C) to 1600 K (1327 °C) and will incorporate an integrated sample holder and heater system that accommodates any solid material (homogeneous materials, composites, and painted or coated materials) up to 3 cm (1.2 in.) in diameter. Sample temperature will be measured using a combination of thermocouples and a multi-wavelength optical pyrometer. (For more information on the Space Environmental Effects Laboratory, visit: http://ed.msfc.nasa.gov/em/em50.html.)

The second test system will provide emissivity measurements from 1600 K (1327 °C) to 3000 K (2700 °C). It uses MSFC's unique Electrostatic Levitator (ESL) system, which heats samples without a crucible. An electrostatic field will levitate each sample to prevent it from contacting contaminating containers, and a laser will heat the sample. This system accommodates spherical samples from 2 to 3 mm (0.08 to 0.12 in.) in diameter. (For more information on the ESL, visit: http://esl.msfc.nasa.gov.) New optical detection technology for both systems is being supplied by industry partner AZ Technology Inc., in Huntsville, Alabama.

Potential Future Activities

When HiTEMS is completed, it will be the only U.S. test system capable of using a high-quality optical system to measure emissivity in a vacuum over such a broad range of temperatures. As materials are tested for emissivity, these data can be entered into NASA's Materials and Processes Technical Information System (MAPTIS) databases where they will be accessible to spacecraft designers, thermal engineers, and others. Moreover, this testing capability can provide data for industry and other government agencies, especially for applications that require operations at high temperatures, such as nuclear power.

Capability Readiness Level (CRL)

This AME task is creating a new laboratory capability for measuring thermal performance of high temperature materials under thermal vacuum conditions that simulate space and lunar surface environments. The creation of this facility elevates this type of testing technology to CRL 5. HiTEMS will help designers characterize material emissivity for high temperature systems used in the Crew Launch Vehicle, the Crew Exploration Vehicle, and in future nuclear-powered and nuclear-propelled spacecraft.

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